14. Test at Ford

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Abstract. This report describes the test of the Ergotool module of the E/S tool and the participative procedure performed at the Final Assembly shop of the Wayne plant at Ford Motor Company, Michigan, USA. Three stations were selected, videotaped, measured, and evaluated according to the Ergotool and evaluated in the participative procedure. The test was very successful. Several cultural and/or company differences could be seen especially compared to Volvo Cars. The fixed organization at the shop floor with no rotation or work enlargement in combination with the very strong focus on mass production and actual costs was the main differences that influenced the usage of the PSIM environment. The PSIM tool and procedure could be used at the Wayne plant but this case study pinpointed the importance of making them possible to implement in a flexible and easy to adjust way. In addition, Ford and the Wayne plant was given an example of how ergonomic issues can be treated in a participatory way and what benefits rotation and work enlargements can give on ergonomic aspects.

14.1 Introduction

This report describes the test of the Ergotool module of the E/S tool and the participative procedure performed at the Final Assembly shop of the Wayne plant at Ford Motor Company, Michigan, USA.

The objective of the test was to generate ideas for improvements in efficiency and health of a part of an assembly line at Ford in the area of ergonomics. A complementary aim was to evaluate the ergotool and the participative procedure in a company belonging to the American culture.

Ford Motor Company, the owner of Volvo Cars Corporation (one of the PSIM partners) was willing to participate in this study with the goal to compare and learn about ergonomics in Europe and at Volvo Cars. The Wayne plant was selected because it was one of few plants where the union had two ergonomic representatives working full time with ergonomic issues. The ergonomic work was carried out in well-organized LEC meetings with a tremendously interested workforce and several good results had been reached.

The Ergotool test at Ford focused on the module physical load. The other modules, safety, mental load and process flow, were demonstrated to the working group, but not tested.

14.2 Test Site Description

The car produced in the Wayne Plant was Ford Focus 4-door Sedan & Combi Coupé. The Wayne Plant produces about 450 000 cars per year at a line speed of 78 cars per hour, two shifts per day.

The Focus had been produced at the Wayne plant for about two years so the production was in a stable condition and no major changes was taking place at the time of the study.

The plant was originally built in the 1950s. New equipment and tools had been installed several times since then, but most of the equipment present at the line today was from the introduction of the Escort in 1989 as no major modernization was made due to the change of models.

14.2.1 Organization

The Factory was divided into 4 areas/shops: Stamp, Body, Paint and Assembly, and has support functions such as Manufacturing Planning, Plant Vehicle Team, Quality, Control, Human Relations, Material Planning & Logistics.

The final assembly plant was divided into two areas, which were managed by a superintendent. Each area was further divided into Zones, 12 zones in total. Each zone had approximately 65 operators employed. Each operator has his own job which he repeats app. every 50 second. Normal working hours is 10 hours a day (8 hours plus 2 hours overtime is normal), 5 days a week. No rotation or 'long jobs' existed. Vacancy replacements and relieve men were used in case of absenteeism.

In the Final Assembly there were 15-20 different job classifications, specified in agreements between the operator and the Plant. Each class requires different qualifications and pays wages accordingly. This makes rotation between jobs impossible. The plant had several different unions and thereby different union agreements regulating the work organization. The Final Assembly had an 'old' agreement while the Stamp & Body shops in the same plant had a modern agreement.

The union was very strong and had a strong influence especially on ergonomics. At the Wayne plant there was a local agreement that in addition to the national agreement supported two Health & Safety and two Ergonomic Representatives. Ford Motor Company paid all of the Union representatives.

To work for a Ford plant was generally considered 'good work' and there were always people in line for work. Wages in the Final assembly were approximately 25$ per hour, up to 100,000$ per year (a little higher in the Body shop, 26$ per hour). Normal work hours were 6:10 a.m. - 4:00 p.m., 10 hours every day, if no reason for low production exists. Overtime is considered normal and can not be turned down, but is paid 1,5 times the money. It is also mandatory to work 6 weekends, if required. Extra hours can be taken out as spare time.

14.2.2 Ergonomics at the FORD Wayne Plant

A large spectrum of ergonomic activities was taking place at the Wayne plant. During the short time present only an overview of the activities in the final assembly shop could be captured. A short summary of these activities is presented below.

The ergonomic evaluations are mainly performed on problem stations and are initiated by complaints from the operators or by statistics of hospital calls. The union ergonomic representatives or the health & Safety representatives mainly perform the evaluations made today at the Wayne plant. Capturing problem areas is done by the ergo representatitives (or health and safety representatives) by discussion with the operators at their workstations. The problem points and possible solutions are then forwarded to a multifunctional group; Local Ergonomic Committee (LEC), where negotiation about actions required and costs takes place. Each possible investment has to be strongly motivated from a cost/benefit perspective. Actual costs and emergency calls to the hospital are at focus and dealing with proactive actions and possibilities of injuries to occur has been problematic so far. The LEC had the power to stop a very bad solution from coming on future car models in the plant (NO BUILD). But so far they had no cooperation with the manufacturing engineering concerning new car models early in development phases. Most ergonomic remedies and projects were paid from a found owned jointly be the Union and the Company.

Several tools are used for performing the evaluations. Except for practical tools such as weight and force measuring of tools, also software tools for the actual analysis were used. A Ford-developed tool called ErgoPlus, implemented on the Intranet was used for different kinds of physical load evaluations. The ErgoPlus was a combination of several well-known standards and tools such as Niosh and Rula. The problem areas found were then documented in a computer-based program called ErgoRX. The ErgoRX was newly developed and had the purpose of documenting problematic stations to use as 'lesson learned' for future projects.

There is no implemented procedure for scanning all stations from an ergonomic viewpoint and thereby no evaluation record of every station.

14.3 Test Procedure and Implementation

In order to make this test several preparatory actions were taken by both PSIM participants and the Wayne plant. A preliminary definition of the stations of the assembly line to be evaluated and setting up a working group to be involved in the test had been carried out prior to the actual test.

During the introduction day of the test several presentations about PSIM, Volvo, TNO and Ford were made and questions and discussions were frequent.

At the test site the selection of stations to study was revised due to the present situation. Three stations were selected, videotaped, measured, and evaluated according to the Ergotool.

14.3.1 Selection of Stations

The following three workstations were selected:

- Hanging on doors,
- Tire station,
- Muffler station.

The station hanging on doors was selected because a similar workstation at Volvo Cars had been part of the Ergotool test, as well. These two stations at Ford and Volvo could then be compared.

The second station (tire station) was selected because it had just been improved and it would be interesting to show the outcomes of the Ergotool concerning this workstation.

The third workstation was chosen because Ford wanted this station to be analyzed. This station had a high priority at Ford to be improved because of many ergonomically problems.

14.3.2 Video and Measurements

At every workstation two ergonomic experts performed the following activities:

- A video was taken of operators performing their tasks/job. Movements, postures and all activities were all recorded, several times,
- Weight of parts and tools were measured,
- Forces (pulling and pushing) were measured,
- Distances (walking, reaching etc.) were measured.

Operators were asked to do their job as they usually do.

14.3.3 Evaluation of Workstations

Every workstation was analyzed with help of video, the measurements taken and the Ergotool. First, the tasks performed at every workstation were listed in the Ergotool. In the next step, every task was analyzed with respect to physical load. This was done in the Ergotool using the video for analyzing posture, task time, and frequencies. Data from the video and from other measurements were entered into the Ergotool. Risks concerning physical load were made. Ergonomic experts from TNO & Volvo made this analysis, the Wayne plant ergonomic representatives were not involved.

14.3.4 Procedure of Group Sessions

The procedure tested at the Wayne plant was the participative part of the tool specific PSIM procedure. The aim of the procedure was to gather all parts with interest in the specific ergonomic issues to be analyzed. The procedure used for the group session was in line with the general PSIM procedure.

After filling in the Ergotool, a program was made of the group session, concerning steps, time schedule and participants. Participants were invited: operator(s), FPS co-ordinator, ergo & health and safety representatives, union representative, manufact-uring engineering (Plant Vehicle Team, responsible for smaller product changes and process-related changes), Ergonomic Engineer (development organization, responsible for ergonomics in new car projects/large changes to the existing car into a plant).

The procedure of the group session was planned as follows:

- *Introduction of participants*: who is who and what function,
- *Introduction to the session*: aim and program,
- *Video presentation of the job*,
- *Inventory of tasks on the flipover (paper)*,
- *Inventory of problems on the flipover with help of the video*: Ergonomic problems and other problems. Participants were asked to present any kind of problems they could think of in relation to the station,
- *Discussion on the problems*,
- *Inventory of possible solution*: Participants were asked to choose most important problems and to come with any kind of short-term solutions and long term solutions,
- *Showing results in the Ergotool*: Ergonomic risks were showed using the Ergotool.

These activities were performed three times in three group sessions, one for each workstation: hanging doors, tire station and muffler station. Two ergonomic experts were facilitating the session.

14.4 Ergonomic Results

In the following section the results from the expert evaluations with the ergotool is presented for the three stations selected followed by comments, further problem definitions and possible solutions discussed at the workshop session.

14.4.1 Station 'Doors On'

The first station to be analyzed was the 'hanging on doors'. One operator hanged each of the four doors.

At the *door station* the following activities were observed as well as identified by the working group:

1. Getting the lifting tool,
2. Fetching the door,
3. Moving the door-and-lifting tool to the car,
4. Attaching the door to the car,
5. Assembling the electrical cable,

6. Hanging the door onto the hinges,
7. Fastening the electrical cable,
8. Hand start the screws,
9. Fastening screws with power tool,
10. Removing the lifting tool,
11. Handling the lifting tool.

These tasks are performed for eight to ten hours a day.

Both the group and the ergonomics identified the following problems, see Table 4.1, as a physical load problem, with the problems in bold being the most severe according to the worker.

Table 14.1 Identified Problems at the Doors-On Station

Tasks/Activity	*Physical load problem*	*Remarks*
Getting the lifting tool	Pushing and pulling	Tall person can hit his head
Fetching the door	Pushing and pulling, sometimes manually lifting (20 kg) because door gets stuck on carrier	Maintenance problem. Causes physical and quality problems Possible solution: maintenance?
Moving the door + lifting tool to the car	*Pulling. Lifting tool is heavy*	Possible solution: Redesign tool (like Volvo tool?)
Attaching the lifting tool to the car	Twisted/lateral bending trunk	Clamp: too much pressure on car
Assembling the electrical cable	Twisted/lateral bending trunk	
Hanging the door onto the hinges	Static posture: twisted/lateral bending, pushing, Lifting door to hinges	There is not enough pressure to fetch door from fixture. Doors are not fitting properly (quality?)
Fastening the electrical cable	Bent wrist. Twisted/lateral bending trunk	Little room to fasten cable/wire. People get restrictions (hospital). There is no proper tool Possible solution: in product design?
Hand start the screws	Twisted/lateral bending trunk	
Fastening screws with power tool	Torsion moment in wrist and arm; twisted/lateral bending trunk	Air tool gives too much torque
Removing the lifting tool	Pushing	
Operating the lifting tool	None	Handle and buttons are ok

During the group session the operators added some general problems: The work area is too small and there is too much people traffic.

According to the Ergotool (guidelines) some additional risks were considered:

- Pushing and pulling the lifting tool. An initial force of 80 N was measured in one direction. Pulling with whole body (8 kgf) is identified as green. Pulling the door with only two arms (not a whole body activity) will be yellow when the force exceeds 8 kgf and red when it exceeds 14 kgf. Force for turning the lifting tool could not be measured, but was estimated to be much higher: at least 16 kgf. As the worker identifies pushing and pulling lifting tool and door as a problem too, this workstation could be improved by redesigning the lifting tool. Volvo recently developed a new (light) lifting tool,

- Possible risks (safety) due to moving doors into the workstation,
- Working posture: twisted and lateral bent trunk during mounting the door to the car. Body weight is mostly on one leg. Risk is identified as red because the summed task duration is more than 4 hours (8-10 hours). The moving 'platform' in this station has improved the situation as much as possible; operators do not have to walk alongside the car. There is not a platform like this at Volvo. Still the working posture at this station is twisted,
- Twisted and bent neck while mounting the door. Risk is identified as red because the summed task duration is more than 4 hours (8-10 hours),
- Torsion moment in wrist and arm while using the power tool.

In conclusion this station would be marked as red in the Ergotool.

14.4.2 Station 'Tires On'

The second station to be analyzed was the 'tires-on' station. One operator was putting on both front and back tires.

At the *tire station* the following activities were observed as well as identified by the working group:

1. Fetching/rolling the tire,
2. Putting the tire on the pins,
3. Using tool to hold the tire,
4. Assembling the nuts (with a tool).

These tasks are performed for eight to ten hours a day.

Table 14.2 Work Session Identified Problems at the Tire Station

Tasks/Activity	*Physical load problem*	*Remarks*
Fetching/rolling the tire	None	Workstation has been improved. No carrying or lifting
Putting the tire on the pins	None	
Using tool to hold the tire	None	
Assembling the nuts (with a tool)	None	Sometimes: twisting fingers

No major problems were identified by the workers, as seen in Table 14.2. There was only one single remark: sometimes rubber is coming off the tires (dirty).

At the *tire station* a few possible risks were considered with the help of the Ergotool:

- Forward trunk bending (0-20°) for more than 4 hours: green,
- In some cases arm elevation during mounting tires. Only when operator stands straight there will be some arm elevation. Instructions will be important,

- Pushing with hand and arms. It was not possible to measure forces. Frequency is 156 times per hour (2 tires per car), task duration is 10 hours, pushing on elbow height will identified as yellow when the force exceeds 8 kgf and red when it exceeds 14 kgf.

In conclusion at this improved station there is no lifting or carrying anymore (green). Trunk bending is (0-20) also considered green. Arm elevation (20-60) depends on personal working method: some operators elevate the arm, some operators don't (green/yellow). Risks of pushing are not considered, as forces could not be measured.

14.4.3 Station 'Muffler On'

The third station to be analyzed was the 'assembly of the muffler'. The muffler was picked up and assembled in one piece, by one single operator. For connecting it at the front assistance of another operator is needed.

At the *muffler station* the following activities were observed as well as identified by the working group:

1. Taking muffler from the packaging,
2. Carrying the muffler to the car,
3. Holding muffler while waiting,
4. Lifting muffler to the car,
5. Mounting the muffler on to suspension,
6. Fastening two clips in the body,
7. Moving the dividers away,

These tasks are performed for eight to ten hours a day.

Both the working group and the ergonomics identified physical load problems (see Table 14.3), with the problems in bold being the most severe according to the worker.

At the *muffler* the following possible risks were identified with the help of the Ergotool:

- Lifting muffler (15 kg) from racks in bent posture, 78 timers per hour: Red,
- Carrying muffler (15 kg) over 4-8 meters (on shoulder level), 78 times per hour: yellow,
- Lifting muffler above shoulder/head level with two persons, 78 times per hour: red,
- Arm elevation > 90 °, summed task duration > 4 hours a day: Red,
- Some possible safety risks.

Table 14.3 Identified Problems at the Muffler Station

Tasks/Activity	*Physical load problem*	*Remarks*
Taking muffler from the packaging	**Lifting (15 kg) in bent posture (78 times per hour): Red**	Muffler sometimes stuck in the racks Wrong muffler is picked because of wrong ticket, then another muffler must be picked up
Carrying the muffler to the car	*Carrying (15 kg) over 4-8 meters. Yellow*	Too many racks spread out
Holding muffler while waiting	*Carrying*	Operator has to keep up with the speed and has to wait for other operator
Lifting muffler to the car	Lifting (15 kg) with two person above shoulder level: Red	
Mounting the muffler on to suspension	Lifting (15 kg) with two person above shoulder level: Red	
Fastening two clips in the body	Arm elevation >90°, summed task duration >4 hours a day = red	Sometimes rubbers are missing
Moving the dividers away	None	

During the group session some ideas for possible solutions were discussed:

- Muffler in two pieces? (reduces weight),
- Tool to lift/hang one end of the muffler first,
- Lifting tool,
- Job enlargement,
- Indexing machine: muffler is delivered on working height, next to the work-station,
- Rubbers could be mounted at the muffler station.

In conclusion this station was evaluated as a high-risk station due to many reasons and turned out very red in the ergotool.

14.5 Evaluation of the Software and the Procedure

The evaluation was made mainly by the union representatives and the Ergonomic Engineers together with the PSIM testers.

14.5.1 Procedure

The general conclusion was that the procedure brought a lot of good aspects such as involving the operators and has all stakeholders present at the same time. The procedure that gave a lot of new information, especially from the operators as direct comments reached the engineers without any in-between info carriers. Especially interesting was also the discussion about several other problems such as quality and maintenance that was brought up because they seemed to be connected to the ergonomic problems. These problems had earlier been put forward through different channels for different reasons, but could here be connected to ergonomic problems.

However this works fine in theory, at the Wayne plant it was very hard to gather those people for one occasion and it will be almost impossible to do it on a regular basis. The worst part is to take the operators from the line for a longer period that 30 minutes. That requires great planning and can be subjected to change due to whatever production problem that comes at hand. The work organization and the culture at the Wayne plant make this kind of procedure very hard to perform.

For very specific occasions however, this could be a possible procedure. Examples of such situations are major changes or severe problems where no solutions have been found.

A suggestion that was made due to the above comments was a procedure with shorter sessions with the operators to collect their view of the problems, and then continue without operators. When one or several solutions are found, another session with the operator can take place to give feedback and get comments on the solution.

14.5.2 Ergotool

The general conclusion was that the Ergotool could be useful in a procedure that fits the organization. The analysis provided were relevant and the figures and border values did correspond to a large extent to what was used at Ford.

Some following suggestions for improvements were made:

- The software/interface must be easy to use,
- The tool must show why a task gets red. The guidelines should be incorporated in the Ergotool,
- Input parameters as well as the outcome ('borders') must be well defined for the user,
- The tool must give feed back which factors are critical: for instance during lifting: horizontal factor or weight is critical,
- The tool must be useful for evaluation during product design and production.

In general, a tool for detecting and selecting stations or jobs with high potential of ergonomic risk was searched for. A tool that could help with what actions that should be taken after the analysis would be of great assistance at Ford in combination with the ErgoPlus tools that are used today.

14.6 Conclusion

In conclusion, the test was very successful. It gave Ford, Volvo and the PSIM project (as representatives from the EU community) a possibility to exchange knowledge about dealing with ergonomic issues. Several cultural and/or company differences could be seen, especially compared to Volvo. The fixed organization at the shop floor with no rotation or work enlargement in combination with the very strong focus on mass production and actual costs were the main differences.

Ford and the Wayne plant was given an example of how ergonomic issues can be treated in a participatory way and what benefits rotation and work enlargements can give on ergonomic aspects. Several study participants at the Wayne plant also

became aware of a wider range of problems at one of the stations (doors on) as well as the connections to the ergonomic problems reported earlier.

The PSIM tool and procedure could be used at the Wayne plant but this case study pinpointed the importance of making them possible to implement in a flexible and easy to adjust way. The values used in the tool as well as what to highlight as red, yellow and green must cooperate with the company procedures and policies of making remedies. Also, the participatory procedure must be able to adapt to the company situation as well as existing committees and tools. In this case, make the operator involvement shorter in time and thereby more focused.

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